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Brief 69-10113

NASA TECH BRIEF

Surface Temperature Mapping with Infrared Photographic Pyrometry

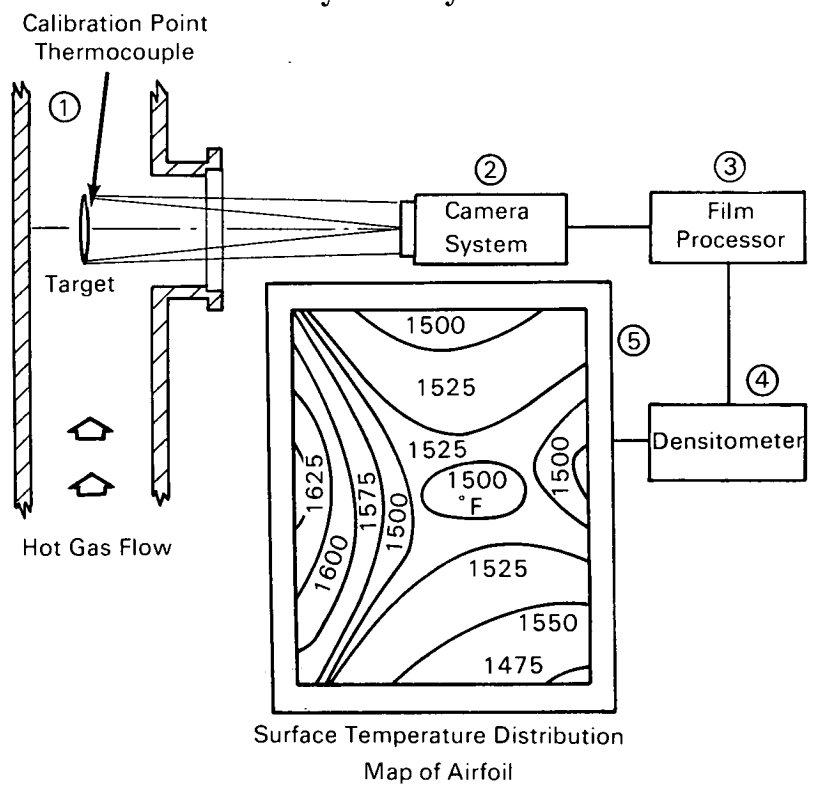

FIGURE 1

A method has been developed for using infrared photographic pyrometry to measure and map the temperature distribution on a heated surface with a high degree of accuracy and precision. This method involves the collection, detection and measurement of a narrow bandwidth of emitted infrared radiation. Standard commercially-available equipment is used, together with systematic procedures. These procedures, compared to conventional methods, can produce higher accuracy, extend the range of temperatures measured, and simplify data handling.

The system is shown schematically in Figure 1. Major components include: (1) the heated surface or "target" to which at least one reference thermocouple is attached in the area to be photographed; (2) an optical viewpath and camera for recording the thermal radiation on infrared-sensitive film; (3) a closely-controlled film developing system; (4) a densitometer for

(continued overleaf)

measuring and recording the densities of the photograph image and plotting contours of equal density; and (5) a method for converting the image densities to corresponding temperatures.

The relation between image densities and corresponding temperatures is established and calibrated in three steps:

1. The relation between relative radiant energy and surface temperature is computed using Planck's fundamental black body law. (Note: Although the emissivity of the heated surface is less than for a black body, actual values of emissivity are not needed since calibration depends only on the change of radiation with change of temperature. This relation is the same for any value of surface emissivity. Hence the use of black body emissivity for convenience.) A typical plot of relative radiant energy versus surface temperature is shown in Figure 2, lower left.
2. The relation between photographic image density and relative film exposure energy is obtained by photographing a conventional calibrated stepped exposure scale illuminated with a constant amount of energy. A calibration is obtained from the step densities of the resulting image. (Note: For accuracy, each film strip used is individually calibrated.) A typical plot of relative film exposure energy versus film density is shown in Figure 2, lower right.
3. The two plots are aligned using a temperature measured by a reference thermocouple on the target surface. The temperature measured by the thermocouple is located on the upper plot; the film density at the thermocouple location as measured by the densitometer is located on the lower plot. Both plots are drawn with the same abscissa scale. The plots are aligned by matching vertical lines drawn from these two points, as shown by the dashed lines in Figure 2. With the two plots aligned, density values can be related directly to the corresponding temperatures.

Notes:

1. Infrared photographic pyrometry has several major advantages over the more conventional surface thermocouple arrays or radiation pyrometers. These advantages are significantly enhanced by use of the method described. A thermal photograph of an entire heated surface can be taken in one second or less. Complete temperature distribution data can be obtained without physically contacting or interfering with the heated surface, except for the reference thermocouple. The thermal photograph provides a permanent record for immediate or subsequent analysis.
2. This method was investigated for use in measuring and mapping surface temperatures of stationary turbine vanes operating in the range of 1000° to 2500°F.
3. Documentation is available from:
   Clearinghouse for Federal Scientific and Technical Information
   Springfield, Virginia 22151
   Price $3.00
   Reference: TSP69-10113
4. Technical questions may be directed to:
   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B69-10113

Patent status:

No patent action is contemplated by NASA.

Source: Frank G. Pollack and Robert O. Hickel (LEW-10763)

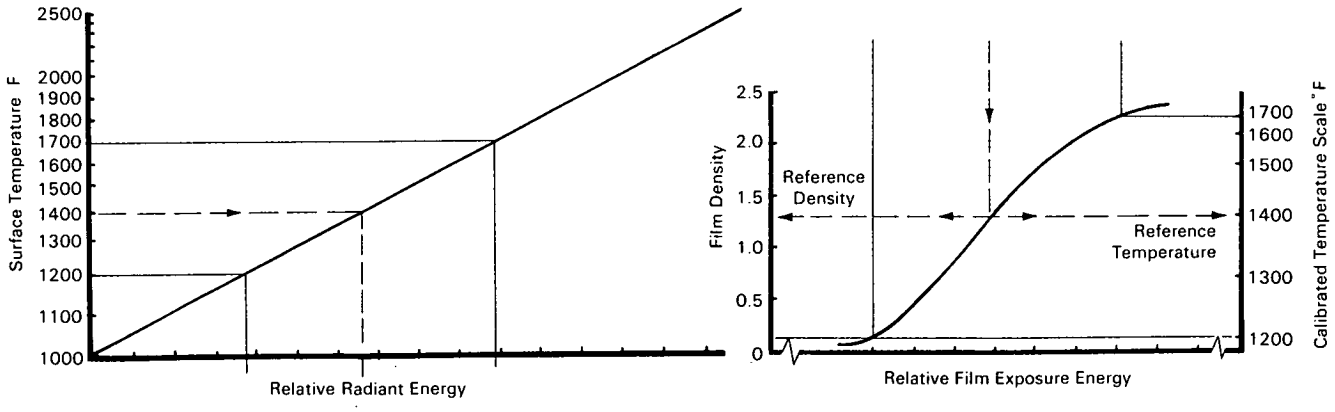

FIGURE 2